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Fostering the Use of Online Learning Resources: Results of Using a Mobile Collaboration Tool based on Gamification in a Blended Course

Over the past years, higher education institutions have been exploring different mechanisms to adapt their learning and teaching practices to increase students' engagement. One of the proposals has been to reuse Massive Online Open Courses (MOOCs) as Small Online Private Courses (SPOCs), or as complementary resources in traditional courses through blended learning practices, such as flipped classroom. However, the integration of online courses as a complement to face-to-face courses poses some challenges. First, students are not used to such blended learning approaches and it is generally difficult for teachers to motivate them to access online resources for the preparation of face-to-face sessions. Second, students are not used to the dynamics of blended learning scenarios, which are less teacher-centered and require their active participation. We propose the use of the mobile application MyMOOCSpace (MMS) to meet these challenges and increase students' motivation and use of learning resources in blended learning courses that use SPOCs as a complement. MMS is a mobile learning application based on gamification mechanisms to promote collaboration and motivation of students in the use of digital resources as a complement to blended learning courses. In this paper, we present the results of a quasi-experiment in a blended course with 294 students that uses a SPOC as a complement, with the aim to assess the effect of MMS on students' motivation and learning resources consumption. In particular, the behavior of two groups of students with the main digital resources of the SPOC (videos and formative assessments) was analyzed: one using the MMS (GTest group), and the other not using MMS (GTrad group). The results suggest that the use of MMS had a positive correlation with the videos consumption, besides increasing student' interaction with assessment exercises in the SPOC.

Keywords—SPOC, mobile learning, gamification, collaboration, blended course.

Introduction

Traditionally, universities have courses in their study programs that have a classroom regime in which students receive the contents through an expository lecture, practices and/or laboratories. However, the high demand for higher education has led universities to incorporate transformation processes in their teaching-learning methods. To do so, some universities have incorporated strategies and platforms that meet that demand through the development of MOOCs (Massive Open Online Course) and SPOCs (Small Open Online Courses) (Bruff, Fisher, Mcewen, & Smith, 2013; Cooper & Sahami, 2013; Delgado Kloos et al., 2014). Moreover, some universities have started looking for new blended learning models that integrate MOOCs and/or SPOCs into their daily practices and transform their traditional classes into more student-centered experiences (Pérez-Sanagustín, Hilliger, Alario-Hoyos, Kloos, & Rayyan, 2017). Some of these models propose a fully online experience through SPOCs, while others propose a more blended learning approach, using SPOCs as a complement for traditional face-to-face classes. In this latter model, students may work online in the SPOC before face-to-face sessions and, teachers may use face-to-face sessions for more “hands on” activities or practical work, this being an example of implementation of a flipped classroom in a blended learning course (Alario-Hoyos, Estévez-Ayres, Delgado Kloos, & Villena-Román, 2017).

Blended Learning is an ambiguous term with different definitions depending on the author and the context in which it is applied (Briz-Ponce, Juanes-Méndez, & García Peñalvo, 2014). So and Brush (2008) define Blended Learning (BL) as “any combination of teaching systems and methods, including face-to-face instruction and the use of computer technologies in a synchronous and asynchronous manner”. Other researchers such as Koper and Tattersall (2005) use the term from a more technological perspective to refer to the combination of face-to-face classes with technology-supported activities to enrich educational experiences by mixing the virtual and the real. Pérez-Sanagustín et al. (2014) define BL in a broad sense as learning that occurs as a combination of formal and informal activities that take place in different environments (physical or virtual) mediated by technology in the same teaching-learning process. In this article, we adopt the definition of Pérez-Sanagustín et al. (2014), which provides a broad definition where face-to-face courses can be supported by a SPOC and other complementary technologies.

Recent work shows that BL practices can be as effective as the traditional teacher-centered approach (Castro, 2019; Huang, Hew, & Lo, 2019). These articles highlight as key for moving towards more student-centered approaches to involve the student as an active actor in the learning process. However, this transformation entails different challenges that need to be addressed. First, students are not used to and do not necessarily follow the pace of BL practices, which require the student to be more autonomous and sometimes work on educational contents before the face-to-face class (Pérez & Saker, 2016). Second, students are not always active in the sessions that take place in the classroom, which makes it difficult for the teacher to follow their progress in the course (Rodríguez, Hernández Correa, Pérez-Sanagustín, Pertuze, & Alario-Hoyos, 2017; Shih, Liang, & Tsai, 2018).

To face these challenges, some researchers have proposed solutions aimed at motivating students so that they play a more active role both inside and outside the classroom. One of these solutions is, for example, the incorporation of complementary technologies and platforms, such as SPOCs, where educational resources are deployed in order to foster the use of educational resources related to the course outside the classroom (Castaño Garrido, Maiz Olazabalaga, & Garay Ruiz, 2015; Duart & James, 2015; Fox, 2013). Shih et al. (2018) states that the value perceived by students when interacting in physical classrooms is directly related to their intentions to participate in the SPOC and depends on the quality of online learning activities (Shih et al., 2018). Meanwhile, Liu, Sands-Meyer, and Audran (2018) performed some experiments using a student response system (SRS) inside the classroom (e.g., Kahoot!, Socrative…). This type of tools allows students to answer questions associated with the course contents and can be used to analyze four variables related to students: academic performance, motivation, self-efficacy and participation in activities. The use of SRS may increase learning, motivation and students’ self-efficacy in learning, and also students’ participation and commitment in class activities of the BL process (Liu et al., 2018). In addition, the incorporation of SRS in the classroom allows teachers to better structure BL courses.

Other studies show that the use of some mobile applications in BL courses may have positive motivational effects, and are also a good mechanism for promoting students' self-learning (Lopez de la Serna & Castaño Garrido, 2018; Ramírez-Donoso, Pérez-Sanagustín, Neyem, & Rojas-Riethmuller, 2015). The idea of complementing BL courses with mobile applications is based on previous studies that show that users of MOOCs and SPOCs tend to prefer more and more the use of mobile devices to access the course contents (Concari, 2014). A study by Sun, Yao, You, Du, and Luo (2018) explored the relationship between students' behaviors towards mobile learning and their personal qualities. They obtained the following results for students who used mobile devices to access course contents: 1) access to course contents more often and for a longer time; 2) positive impact on students' learning behavior, helping them achieve higher scores on the course exams. This can help students maintain interest in meeting the challenges of the courses to be taken through permanent access to information (Kadek Suartama, Setyosari, & Ulfa, 2019).

However, despite the potential that mobile devices have shown as a complement to face-to-face classes, there are still few experiences published and reported in the literature that demonstrate the effectiveness of their use in SPOC-based BL courses. To contribute to the expansion of the literature regarding this type of environments, this article presents a quasi-experiment that examines the impact of a mobile application called MyMOOCSpace (MMS) in promoting the consumption of learning resources in a SPOC when used as a complement in an BL course. MMS is a tool designed to foster collaboration among SPOC participants through gaming components, which allows for active motivation for learning challenges (Ramírez-Donoso, Pérez-Sanagustín, & Neyem, 2018; Ramírez-Donoso, Rojas-Riethmuller, Pérez-Sanagustín, Neyem, & Alario-Hoyos, 2017)

The quasi-experiment was conducted in the SPOC "Systems Programming" of Universidad Carlos III de Madrid (UC3M), in Spain. It was performed on the sample of 294 students from which 97 used the MMS tool (the treatment group or "test", GTest) and 197 did not us it (control group or "traditional", GTrad). The aim of the quasi-experiment was to understand the behavior of these two groups of students in relation to the consumption of learning resources. Specifically, the following research questions were evaluated:

(RQ1) How does the use of MMS influence the consumption of SPOC learning resources? and
(RQ2) How does the use of MMS correlates with the course passing rate?

Section II presents a literature review in relation to the use of SPOCs in BL courses. Section III presents the details of the quasi-experiment by describing the experimental scenario, the collected data and analysis methods. Section IV presents the results of the quasi-experiment. Finally, Section V presents the general conclusions and future work.

State of the Art

This section presents a review of the literature on the use of SPOCs in BL practices. The impact of mobile learning solutions proposed to motivate the participation of students in SPOC-based blended learning is also analyzed. The objective of this literature review is to understand how to measure learning in this type of BL practices.

a) Difficulties in the enactment of SPOC-based blended learning practices

In recent years, one of the most common approaches followed in the implementation of BL practices has been to incorporate the use of SPOCs as a complement to face-to-face classes (Pérez-Sanagustín et al., 2017). Typically, in the SPOCs the teachers make a virtual replica of the traditional course through video lessons together with formative exercises to complement or support face-to-face courses. BL courses are usually organized into two phases: digital and face-to-face. In the digital phase, students registered in the face-to-face course have access to the SPOC and the tools associated with the course to prepare for their activities for the face-to-face sessions. In the face-to-face phase, the students practice the knowledge acquired in the digital phase (Njie-Carr et al., 2017). According to Zeng et al. (2018), SPOCs facilitate the combination of digital and face-to-face phases to complement the traditional educational model. In addition, and as several studies report, the SPOC in BL practices supports students' individual needs (Wang, Wang, Wen, Wang, & Tao, 2016) improving their effectiveness in the learning processes (Zeng et al., 2018).

To measure the impact of SPOC-based BL practices, some quantitative indicators have been used (Wee Sing & Foon Hew, 2010). For example, Albó & Gelpí (2017) report that this type of practice reduced the level of dropout from the course and increased student participation in access to course content. According to the literature review by Spanjers et al. (2015), quantitative indicators include: (1) results before and after experimental tests; (2) results of examinations or tests of a course; and (3) final course scores.

As qualitative measurements, researchers have been using self-assessment and/or perception surveys, where the differences in scores between the surveys applied before and after the experiment are evaluated. An example of this type of measurement is the one proposed by Wang et al. (2016). The students answered a questionnaire before starting the official face-to-face course and a survey before entering the SPOC designed for this course. At the end of the course and the exams, the students were given a second questionnaire that allowed them to measure the degree of progress, comfort, efficiency, and type of learning with this method and compare it with the initial survey. One of the highlights of the results was that students strongly valued the feedback provided. According to Spanjers et al. (2015), qualitative indicators that influence student behavior include: (1) self-evaluation of the activity through questionnaires about students' perception of skill development, achievement of course objectives, improvements in their learning, and confidence in their skills and knowledge; and (2) self-evaluation through questionnaires administered before and after the experiment to measure perception and motivation.

b) Mobile solutions to complement SPOC-based Blended Learning practices.

There are several studies in the literature that show the possibilities of using mobile technologies as a complement to BL practices. For example, Cieliebak and Frei (2016) evaluated the skills acquired by engineering students in a BL setting supported by mobile tools, showing a higher acquisition of non-technical competences with respect to classical teaching methodologies. Another example is that of Flumerfelt and Green (Flumerfelt & Green, 2013) who showed that the use of mobile devices outside the classroom as a complement to the face-to-face class supports and strengthens students' learning, as they perceive access to materials as a motivating and dynamic process (Pérez-Sanagustín, Parra, Verdugo, García-Galleguillos, & Nussbaum, 2016; Pérez-Sanagustín et al., 2012).

Other BL experiences show the effectiveness and versatility of using mobile devices. One of these experiences is that of de Waard (2013), who presents MobiMOOC. The author proposes the combination of "SPOC platforms and mobile learning" to analyze the situation of complexity and chaos in the field of programming technologies. In addition, de Waard et al. (2012) comment that the combination of these learning formats (mobile learning plus BL) is ideal for maximizing interaction and dialogue among students and encouraging collaborative, informal and permanent learning. According to Raza (2014), mobile access has a positive impact on the students' participation in online and open training courses. In this case, the author examines the advantages of mobile access in different MOOC platform (edX, Coursera, and Udacity, among others) using a native OpenSAP mobile application. The author concludes that the native applications provide more functions than the mobile browser, which favors the students' motivation when facing the resolution of exercises and visualization of contents. In this line, Dalipi, Imran, Idrizi, and Aliu (2017) analyzed the learning experiences of students in a MOOC in two different environments (mobile and desktop PC), concluding that the students preferred the access via mobile device.

In the case of SPOC-based BL experiences, few studies report empirical evidence on the use of mobile devices as a complement. One of the cases is the FlipApp, a mobile app that is used to encourage students to work on the course contents through a SPOC before the face-to-face class using gamification techniques (Cruz Argudo, 2017). This tool is built to work with SPOCs offered through Open edX and provides points for video watching or doing formative assessment activities in the SPOCs, accessing through the browser or the mobile tool itself. Another type of experiences are BL practices with mobile platforms applied, for instance, in medicine courses (Briz-Ponce, Juanes-Méndez, García-Peñalvo, & Pereira, 2016). The results of the research suggest that the performance of students who use apps associated with learning processes on the mobile phone is statistically better than that of students who use traditional methods. However, all studies suggest that mobile devices should be considered as an additional tool to complement the teachers' explanation and that it is necessary to overcome the different barriers and challenges to adopt these pedagogical methods in the universities. In this study, we contribute with a new quasi-experiment that validates the effectiveness of the use of the mobile devices, through an example mobile application called MyMOOCSpace (MMS), in this type of educational scenarios.

Quasi-Experiment

The "quasi-experiment" methodology refers to the experimental research designs in which the subjects or groups of study subjects are not randomly assigned (Rossi et al., 2018). These types of studies typically make the comparison of a treatment group and a control group. Although quasi-experiments are more vulnerable to threats and validity than randomized tests, as they do not require random assignments of students to experimental groups, they are generally an accepted methodology when conducting studies in real learning environments. Therefore, in this article the quasi-experiment is chosen as the most appropriate methodology to understand how the use of MMS influences the use of learning resources in a SPOC-based BL course.

a) Context

The quasi-experiment was performed in "Systems Programming" a course offered at Universidad Carlos III de Madrid to learn Java programming. This course is the second of this type that first-year students of several bachelor's degrees have to take as part of their academic studies. This course was designed to have a SPOC as a complement to the face-to-face classes. The use of the SPOC is voluntary and does not count for the final grade. This SPOC was created and designed on the Open edX platform by the course teachers and is aimed at students of different engineering programs, all related to telematics and telecommunication engineering. The quasi-experiment was performed between the months of February and the beginning of June 2018, months during which the normal semester at the university took place. All students taking the course were part of 5 programs. For this study, and in order to avoid the influence of the teacher, only 3 programs were selected in which the teacher was the same.

MyMOOCSpace (MMS) is the mobile tool that was used as a complement to the SPOC for promoting students' activity with the online resources. This tool works on Android mobile devices only. For the correct execution of MMS during the academic semester the following activities were performed. First, SPOC questions and answers were loaded into MMS database. In this way, the questions and answers of the course were the same as those that students could find in the SPOC. Secondly, the random functionality was applied to show the questions randomly to students in each phase of the game. Each phase of the game was graphically represented by a planet, and each planet contained the contents of a week of the SPOC. Third, game teams were formed. The student teams consisted of 4 members, each one randomly selected by the teacher, generating a total of 24 approximate teams, given that one team was left with 5 members. Each team was asked to work together to make better progress in the game.

An initial survey was sent to all students, both from the treatment group (test group – GTest) and control group (traditional group – GTrad), to understand: (1) if they were familiar with the definitions of collaboration, and (2) if they had previous experiences in mobile games for educational purposes or interacting with other students to solve problems collaboratively. At the end of the process, a second survey was applied only to the GTest. This process was managed through email for each student, obtaining an 80% response from the 97 participants to whom it was sent.

b) Participants and Sample

294 students participated in the experience organized into two groups: the treatment group (GTest) with 97 students, and the control group (GTrad) with 197 students. This assignment to the groups, however, was not done randomly, but determined based on the students who used the tool voluntarily and those who did not use it. Those students who requested access to MMS through email and had a mobile device with an Android operating system were classified under the GTest group. The rest of the students who did not request access to the

tool or that did not meet the Android requirement and that only used the SPOC were classified under the GTrad group.

Within the GTest, students were assigned randomly to different groups for the use of MMS. That is, from all those who downloaded MMS from the university platform and requested access to it, students were randomly assigned into groups of 4-5 people. The students only met the remaining team members once they accessed the tool for the first time. Table 1 shows that 79% of the students belonging to the GTest group used MMS.

Table 1. The use of MMS between the GTest and GTrad groups.

Notes: H0=There is no relation between being a part of the experimental group and having used MMS; Ha=There is a relation between being a part of the experimental group and having used MMS; Pearson $\chi 2(1) = 207.1749$, $p = 0.000$ This result is statistically significant to reject the null hypothesis (Ho) at $p<0.005$.

	Did not use MMS	Used MMS	Marginal Total Rows
GTrad group	197 (100%)	0 (0%)	197 (100 %)
GTest group	20 (21%)	77 (79%)	97 (100%)
Marginal Total Columns	217 (74%)	77 (26%)	294 (100%)

c) Instruments and Data gathering Techniques

We used mixed methods to address the research questions RQ1 and RQ2 combining qualitative and quantitative data (Creswell & Plano Clark, 2011). Table 2 presents a summary of the instruments used for data gathering purposes. All the instruments were validated by the ethics committee of the university of origin of the research (Pontificia Universidad Católica de Chile).

Table 2: Instruments used in the analysis and interpretation of data by Research Questions

	RQ1	RQ2
SPOC Database	√	
MMS Database	√	√
MMS LOGFile		√
Record of the final grades of the course		√
Questionnaires Before and After the quasi-experiment	√	√
Students' final remarks	√	

- **SPOC Database**. This refers to the Open edX database where the SPOC of the Systems Programming course is hosted. Information associated with the consumption of the learning resources of the course, time of use of each resource and the dates in which the resources were used was extracted from this database. It is inferred from the SPOC database who are the students that most frequently consulted the contents and each one of their learning resources (videos and training exercises).
- **MMS Database**. From these data, information associated with the students' behavior when facing each question throughout the different stages of the game was extracted. From this database, it is possible to distinguish those questions that have the greatest access frequency by the students, the time that each team of participants of the game remains in each module of the course, the dates of access to each resource, the scores obtained by the team, a ranking of the teams with greatest participation, among other data. From the MMS database, the

group GTrad (students who did not use the tool) and the group GTest (students who requested access to the tool by email) are identified.

- **MMS Logs**. Text file where the level of use and times of each team per planet were extracted. In addition to this file it is possible to extract the students' behavior in the tool in terms of performance and response times.
- **Record of the final grades of the course**. Students' final grades in the Systems Programming course in a scale from 0 to 10.
- **Before-Test Questionnaire**. PISA derived and validated instrument (OECD, 2016), whose objective is to collect information from students regarding the skills they possess to generate and conduct the processes of course collaboration and motivation in order to encourage the consumption of its learning resources. This questionnaire includes the elements proposed by PISA (OECD, 2016) to measure the individual capacities of each student in the collaborative problem solving (CPS) and the motivation to take the initiative in the consumption of learning resources. With the three main CPS skills, a point of intersection is made with the four stages of problem solving and a skill matrix is obtained that indicates the students' competencies in the aforementioned capacities. To evaluate each criterion, questions were used and evaluated on a Likert scale with values from 1 (minimum) to 5 (maximum), with a total of 21 questions.
- **After-Test Questionnaire**. This questionnaire evaluates the performance of the team after completing the SPOC experience and using MMS. To this end, the four proposed dimensions are evaluated (Smith-Jentsch, Zeisig, Acton, & McPherson, 1998), grouped under the name of Team Dimensional Training (TDT) (Smith-Jentsch et al., 1998): Exchange of information, or what has been communicated; communication, the way in which the information has been transmitted; support behavior; initiative and leadership. The questionnaire consists of a total of 15 questions with answers on a Likert scale with values from 1 to 5.
- **Experience evaluation survey (students' final remarks)**: A questionnaire was developed to collect the impressions of the students regarding the use of the tool and whether or not it was adequate to encourage the use of SPOC learning resources. It also included questions regarding whether they felt that the tool fostered more collaboration when facing the problems so that the team could progress in a better way through each of the phases of the game. This survey is made up of 17 open questions and gathers opinions only from participating students who used MMS.

d) Methods

To answer (RQ1) "*How does the use of MMS influence the consumption of SPOC learning resources?*" we perform a statistical analysis on the delivered responses considering the before and after questionnaires. This analysis was complemented with an analysis of the data recorded in the SPOC and MMS databases to cross check the data of the different students in both platforms.

Analysis of the Questionnaire Applied Before the Quasi-Experiment. According to the different answers and the use of a scale that allows tabulating the results obtained, we generated a skill matrix indicating their competencies. According to PISA (OECD, 2016), students can be classified into three proficiency level groups:

- **Low**. Students who respond little or nothing to the requests of their teammates; their contributions have little value. In general, they work individually, independently from their teammates and they are not motivated to use of SPOC learning resources.
- **Medium**: Students who contribute to the progress of the group only when their participation is required and not proactively. They only make use of the learning resources when it is strictly necessary and only to answer a question or solve a phase of the game.
- **High**: Students who respond and request information from their teammates, resolve conflicts and adapt to changes both in the team and in the context of the problem. They are also responsible and proactive when using learning resources to get the information needed to solve problems.

Analysis of the Questionnaire Applied After Quasi-Experiment. This questionnaire evaluates the performance of the team after completing the SPOC experience and using MMS. To this end, the four dimensions proposed by Smith-Jentsch et al. (1998) are evaluated, grouped under the name of Team Dimensional Training (TDT). From these dimensions, there are three possible values for team performance:

- **Low**: Team with little or no communication, low level of support among members. Leadership skills and proactivity are not perceived.
- **Medium**: There is an exchange of information, but what is communicated is not fundamental. Some level of support is present among the members, but it must be requested explicitly. There may be a leader, but the rest of the members are not proactive.
- **High**: The exchange of information is efficient, with clear terminology relevant to the context. Support and feedback among team members is present, especially with more complex questions.

For the analysis of the data from both databases we used the Wilcoxon test (Figures 1 and 2 show that the data distribution is not normal) comparing the results of the before and after tests of the students belonging to the GTest and the students belonging to the GTrad group.

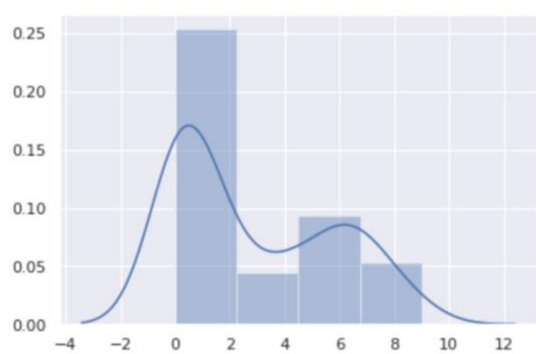

Figure 1: Distribution in GTest

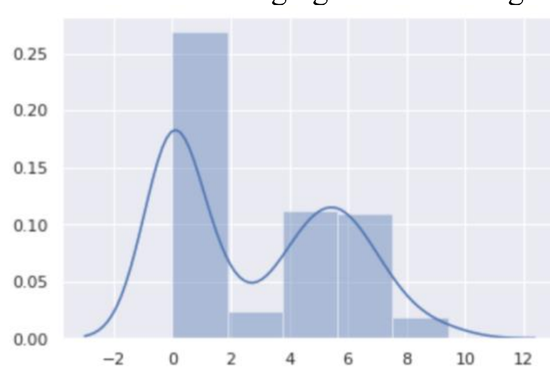

Figure 2: Distribution in GTrad

For the second research question (RQ2), "*How does the use of MMS correlates with the course passing rate?*", we analyzed the final grades and cross-checked with the data collected through MMS and SPOC. This data analysis was done to understand the behavior of the students when facing the challenges proposed in MMS and the SPOC regarding whether there was an increase or improvement in the grades of those students who used MMS.

To evaluate if there are significant differences between the passing rate of the students of the GTest and the GTrad, we performed the chi-square statistical test. In addition, a frequency analysis of the students' interactions with the course was made from the SPOC database. This analysis provides the percentage of consumption of each learning resource per hour during the experiment in relation to the degree of progress of students in the game.

To analyze the impact of MMS on students' performance, we performed a Wilcoxon test comparing the final grades of GTest and GTrad groups. As a form of control, only the results of the students from the two groups that accessed SPOC at least once were compared for this analysis.

Results

At the end of the academic semester, students belonging to the GTest group were invited to answer a survey associated with the use of the MMS tool. Only 60% of the students answered the complete survey, 20% answered partially and the remaining 20% did not participate in the activity. The fact that 40% of the students answered partially or did not respond might be due to the high workload at the end of the semester of because participation was voluntary.

(RQ1) How does the use of MMS influence the consumption of SPOC learning resources?

Tables 3, 4 and 5 show the average number of videos and assessment exercises that were seen by students who used MMS and those who did not, as well as the results of statistical analyzes comparing both groups. The results show that the use of MMS is significantly related to a greater consumption of videos and exercise-problems when compared to those students who did not use it (99% of significance).

Table 3: Summary of statistics to compare the number of videos and exercise-problems seen among students who used and did not use MMS

	Average	Standard Deviation
Videos		
Did not use MMS	51.2	50.31
Used MMS	127.75	10.79
Problems		
Did not use MMS	36.46	34.97
Used MMS	88.87	4.90

Table 4: Number of videos watched among students who used and did not use MMS, according to the Wilcoxon classification. Note: H0=The number of SPOC videos watched by students who did not use MMS is equivalent to that of those who did use the app. $z = -12.397$, $p = 0.000$ This result is statistically significant to reject the null hypothesis (Ho) at $p<0.005$

	Rank Sum	Expected
Did not use MMS	25607.5	33561.5
Used MMS	19542.5	11588.5

Table 5: Number of exercise-problems solved among students who used and did not use MMS, according to the Wilcoxon classification. Notes: H0= The number of SPOC problems solved by students who did not use MMS is equivalent to that of

those who did not use the app. z = -13.364, p = 0.000 This result is statistically significant to reject the null hypothesis (Ho) at p<0.005

	Rank Sum	Expected
Did not use MMS	24988	33561.5
Used MMS	20162	11588.5

Figures 3 and 4 show the relation between the grade obtained by the student (Y axis) and the number of videos watched, or problems solved (X axis). The activity of the GTest is shown in red and in blue is that of the GTrad. The figures show that the students who used the tool watched and solved a greater amount of learning resources and that there is a slightly higher concentration in the grades higher than 4.

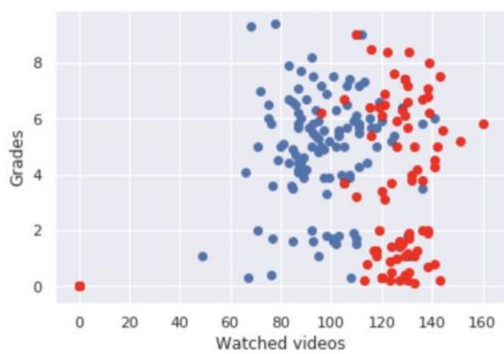

Figure 3: Videos Watched (Red=GTest, Blue=GTrad)

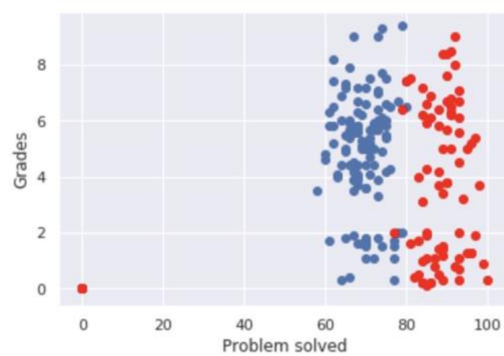

Figure 4: Problems solved (Red=GTest, Blue=GTrad)

(RQ2) How does the use of MMS correlates with the course passing rate?

Table 6 shows that the use of MMS is significantly correlated with passing rates with a significance of 99.5%. The results show that those who use MMS have a higher passing rate compared to those who do not use the tool.

Table 6: Chi-square results to evaluate difference between the passing rates of the students who used and did not use MMS. Notes: H0=There is no relation between having used MMS and passing the course. Ha= There is a relation between having used MMS and passing the course. Pearson $\chi2(1) = 7.9531$, p = 0.005 This result is statistically significant to reject the null hypothesis (Ho) at p<0.05.

	Did not pass the course	Passed the course	Marginal Total Rows
Used MMS	183 (62%)	34 (12%)	217 (74 %)
Did not use MMS	54 (18%)	23 (7%)	77 (26%)
Marginal Total Columns	237 (81%)	57 (19%)	294 (100%)

Figure 5 shows the time of the day when there is a greater number of interactions with MMS and the use of SPOC. The results indicate that the highest frequency of use of SPOC occurred in a range of 2 hours (10:30 am and 12:30 am), which corresponds to the time slot that students had to prepare for the class before entering the classroom in two of the analyzed programs (see Figure 5).

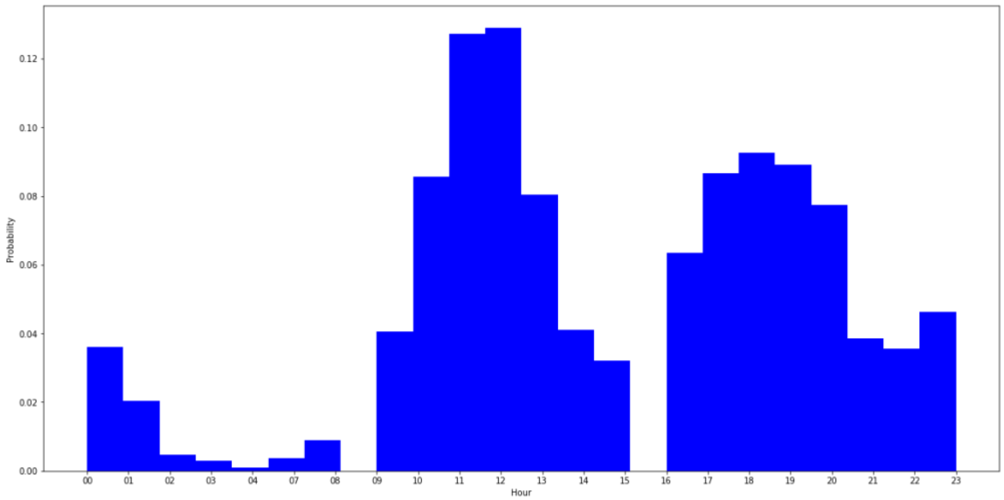

Figure 5: Percentage of frequency of use per hours of videos + exercises

Also, from the MMS database and the final survey of the students, it is concluded that the students belonging to the GTest group accessed more frequently the learning resources in the SPOC. Figure 6 shows the interaction frequency with the different topics of the course during the weeks of the semester. From this it is observed that the topics "Binary Tree" and "Sorting and Searching", corresponding to topics 4 and 5 respectively of the course, are the most consulted.

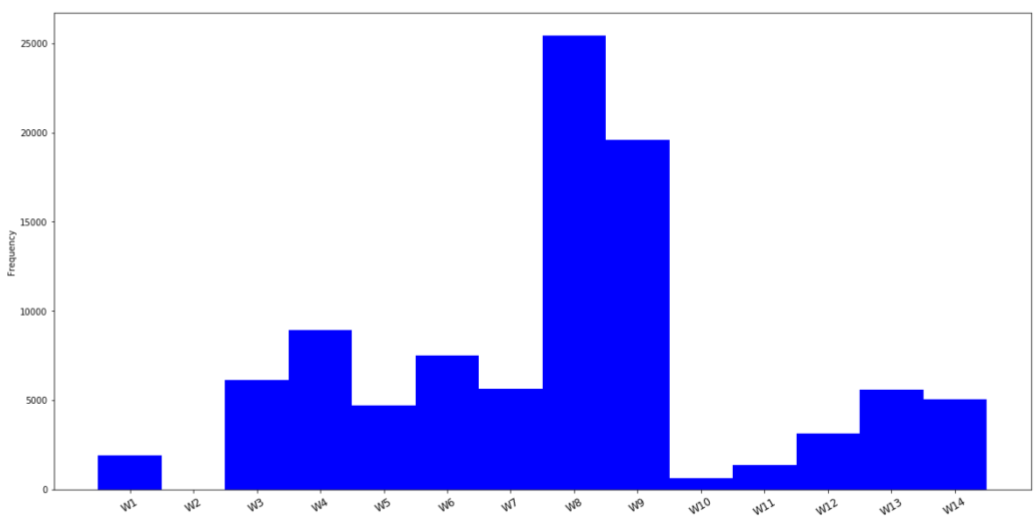

Figure 6: Increase of frequency of use in weeks for videos + exercises

According to the Wilcoxon test and sensitivity analysis, the numbers are still higher compared to the numbers of those who did not use MMS (see Table 3). The chi-square analysis on the passing rate of students using MMS is higher than that of those who did not use it (see Table 6).

Conclusions and Future Work

This study has investigated the relationship between the use of MyMOOCSpace (MMS), a mobile tool based on gaming, and the consumption of learning resources in SPOCs, either videos or formative assessment activities. The results obtained indicate that the use of MMS is correlated with a higher consumption of learning resources and a higher passing rate of the course.

However, and despite the results, this study has some limitations that have to be taken into account for the interpretation of the results. First, it was not possible to have all the partial grades of each one of the students. This would have made it easier to monitor the evolution of the students throughout the semester and to better understand the temporary impact of the tool on their performance. Second, at the implementation level, the tool was only available for the Android operating system, so those students who had other operating systems on their devices could not be considered. This may have biased the results by keeping out the students with devices with other operating systems, although a comparison of the GTrad and GTest groups was possible. Work is being done on the development of MMS for other operating systems and on expanding this study in the future. Third, at the research level, these results are valid for the observed population and are not necessarily generalizable to other study populations or other mobile applications.

However, the results obtained in this work are promising, given that they coincide with previous studies by other researchers (Alario-Hoyos, Estévez-Ayres, Delgado Kloos, & Villena-Román, 2017; Albó & Gelpí, 2017; Artal Sevil, Casanova López, Serrano Pastor, & Romero Pascual, 2017; Bansal & Singh, 2016; Belarbi, Talbi, Namir, & Chafiq, 2017; Cruz Argudo, 2017; Pham & Wang, 2015; Sun et al., 2018). As these and other authors affirm, these tools are promising from a pedagogical point of view, as long as they are used as a complement to active learning practices to promote students' motivation. (Artal Sevil et al., 2017; Briz-Ponce et al., 2016; Briz-Ponce, Juanes-Méndez, & García Peñalvo, 2014; de Waard, 2013).

As future work, the tool will evolve to support new operating systems in order to be able to expand the number of students participating in the experiments and achieve better analysis of student behavior with MMS. In addition, there are plans for the improvement of the gamification components in each level of the game in MMS. However, the most important thing to consider in the future is the strategy of the new quasi-experiment, which will include measuring the impact on student participation, delivering results on the performance made before, during, and after that participation with the tool and with the support resources of each course. In this way it will be possible to raise new hypotheses and research questions associated with whether mobile devices accompanied by applications with gamification components improve the performance of a student during and after the study of a course, providing at the same time, improvements in the aspects of motivation and learning. In order to achieve these improvements in the tool and design of the structure of the experiment, the weekly progress of the group of students categorized as GTest should be measured and thus make valid comparisons with the GTrad group that follows a traditional approach.

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